PB87-10 25 39

Organotin Toxicity Studies Conducted with Selected Marine Organisms at EPA's Environmental Research Laboratory Gulf Breeze, FLorida

(U.S.) Environmental Research Lab.
Gulf Breeze, Fl

Sep 86

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TECHNICAL REPORT DATA
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1. REPORT NO.	2.	3. RI
EPA/600/D-86/216		PB87-102539

4. TITLE AND SUBTITLE	5. REPORT DATE
ORGANOTIN TOXICITY STUDIES CONDUCTED WITH SELECTED MARINE ORGANISMS AT EPA's ENVIRONMENTAL RESEARCH LABORATORY, GULF BREEZE, FLORIDA	September 1986
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Gerald E. Walsh	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS same as #12	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Gulf Breeze, FL 32561	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE EPA/600/04

15. SUPPLEMENTARY NOTES

16. ABSTRACT

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17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	4
	20. SECURITY CLASS *(This page)*	22. PRICE
	UNCLASSIFIED	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

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SPRINGFIELD, VA. 22161

EPA/600/D-86/216
September 1986

ORGANOTIN TOXICITY STUDIES CONDUCTED WITH SELECTED MARINE ORGANISMS AT EPA'S ENVIRONMENTAL RESEARCH LABORATORY, GULF BREEZE, FLORIDA

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ABSTRACT

Studies on effect of bis(tri-n-butyltin)oxide (TBTO) and other organotins on marine species have been conducted at the U.S. Environmental Protection Agency's laboratory at Gulf Breeze, Florida, since 1983. First studies were done on two species of algae, Skeletonema costatum and Thalassiosira pseudonana, where 72h EC50s for tributyltins and population growth were 0.35 and 1.16 µg/l, respectively. Two developmental stages of the lugworm, Arenicola cristata, were sensitive to TBTO (96h LC50=4 µg/l). Only 0.1 µg/l inhibited arm regeneration by the brittle star, Ophioderma brevispina. TBTO was less toxic to the grass shrimp, Palaemonetes pugio, (96h LC50 = 20 µg/l). Continuing studies include research on effects of TBTO on 1-, 4-and 10-day-old mysids and estuarine seagrass communities.

1. INTRODUCTION

Tributyltin (TBT) has been reported to be a contaminant in natural waters (1-3) and is toxic to algae (4-5) and animals (6). Because of its presence in water and toxicity, the Office of Pesticide Programs of the U.S. Environmental Protection Agency (EPA) initiated a "Special Review" in 1986 of TBT with a view toward reevaluation of this substance as an environmental contaminant, particularly in water. Currently, TBTs are registered by EPA as wood preservatives, disinfectants and biocides for use in cooling towers, pulp and paper mills, breweries, leather processing facilities and textile mills under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). The major concern of the Special Review is with TBT in antifouling paints and its potential effects on aquatic organisms.

The EPA Environmental Research Laboratory at Gulf Breeze, Florida, has conducted studies on organotin compounds, particularly bis(tributyltin) oxide (TBTO) since 1983. The objective of the studies is to provide EPA with toxicity data required for evaluation of potential effects of TBTO on estuarine species and ecosystems. This report describes some of the research that has been completed or will be initiated soon.

2. COMPLETED STUDIES

In all studies reported here, concentrations of toxicants, either in stock solutions or in exposure vessels, were confirmed by chemical analyses.

Algae

Walsh et al. (5) described effects of a series of tin compounds on population growth and cell death of two marine diatoms, Skeletonema costatum and Thalassiosira pseudonana. In addition, studies were done to determine if the algae could adapt to continuous exposure. In growth tests, exposures were to inorganic tin (stannous chloride), mono-, di-, tri- and tetramethyltins, di-, tri- and tetraethyltins, di-, tri- and tetrabutyltins, and mono-, di- and triphenyltins. The most toxic group was the tributyltins, including tributyltin acetate, TBTO, tri-n-butyltin chloride, and tributyltin fluoride. The average 72h EC50s (calculated concentrations that would inhibit growth by 50 per cent) for this group were 0.35 µg/l (S. costatum) and 1.16 µg/l (T. pseudonana). The next most toxic group was the triphenyltins, including triphenyltin acetate, bis (triphenyltin) oxide (TPTO), triphenyltin hydroxide, and triphenyltin acetate, with average EC50s of 0.79 µg/l (S. costatum) and 1.19 µg/l (T. pseudonana). All other compounds were much less toxic: dibutyl- and diphenyltins, the next most toxic group, had average EC50s of 41 µg/l (S. costatum) and 156 µg/l (T. pseudonana).

By use of the mortal stain, Evans Blue, Walsh et al. (5) showed that the most toxic compounds killed, rather than attenuated, algae at low concentrations. The 24h LC50s (calculated concentrations that would kill 50 per cent of an algal population) for tributyltins averaged 13.1 µg/l (S. costatum) and 8.9 µg/l (T. pseudonana) and for triphenyltins, 12.2 µg/l (S. costatum), and 3.2 µg/l (T. pseudonana).

Neither algal species adapted to TBTO or TPTO after 12 serial transfers over 12 weeks in contaminated growth medium: 72h EC50s were the same before and after the 12-week exposure.

It was concluded that the algal species tested were senstitive to tributyl and triphenyltins and that adapatation was unlikely to occur if they were exposed chronically to the compounds.

Polychaetes

Larvae of the polychaete, Arenicola cristata, were less sensitive to TBTO, tributyltin acetate (TBTA), TPTO and triphenyltin chloride (TPTC) than algae, with 96h LC50s between 2 and 4 ug/l for TBTO and TPTO and between 5 and 10 ug/l TBTA and TPTC (7). Lethal effects occurred at two developmental stages, and living but morphologically abnormal larvae were common. If larvae at sensitive stages of epibenthic development were exposed during intermittent events, such as tidal flow, survival could be reduced.

Arthropods

Emerita talpoida, the mole crab, is common on sandy shores. It was exposed to TBTO in water or sand in flowing water tests. Concentrations up t 10 ug/l in water and 4,500 ug/Kg in sand did not affect survival during exposure for seven days. Resistance was surprising because E. talpoida was very sensitive to pesticides in similar tests.

Palaemonetes pugio, the grass shrimp, was also relatively insensitive to TBTO. In flowing water tests, its 96h LC50 was 20 ug/l, and 10,000 ug/Kg in sediment did not kill any animals after exposure for 96h. These results were also surprising because arthropods are often the most sensitive to a variety of toxicants.

Echinoderms

Both TBTO and TPTO inhibited regeneration of arms, estimated by length and weight of regenerated material, by the brittle star, Ophioderma brevispina, at very low concentrations (8). In flowing water tests, statistically significant inhibition of regeneration by both compounds occurred at 0.1 ug/l after 30 days exposure. Inhibition also appeared to occur at 0.01 ug/l in all exposures, but this could not be demonstrated statistically. The brittle star arm regeneration test appears to be sensitive for organotins, and it is hypothesized that inhibition of regeneration was caused either by action of the compounds on the nervous system or directly upon dedifferentiated tissue at the point of arm autotomy.

3. FUTURE STUDIES

Arthropods

A comparative toxicity test will begin soon in which mysids, Mysidopsis bahia, of several ages will be exposed to TBTO in flowing seawater. Young estuarine organisms are often more sensitive to toxicants than adults, and one-, four- and ten-day-old mysids will be exposed to TBTO to determine if age is a factor in sensitivity.

Larval and postlarval stages of commercially important penaeid shrimp will be exposed to TBTO in flowing water tests. Testing will be done to identify sensitive life stages so as to predict potential effects of TBTO on this major fishery resource.

Estuarine Ecosystems

Research will begin shortly on possible effect of TBTO on selected aspects of the estuarine seagrass (Thalassia) community. A combination of laboratory microcosms and field plots will be employed to evaluate exposure effects on the number and kind of dominant macroinvertebrates, character of the sediment, chlorophyll content and biomass of seagrass and epiphytes and weight loss of dead seagrass in litter bags. This research will be used for modelling of effects at the community level.

4. CONCLUSIONS

It is expected that toxicity tests on a variety of species that occupy different ecological niches and trophic levels, combined with toxicant evauations at the ecosystem level, will provide understanding of possible effects of organotins in the estuarine environment. Such understanding, built upon a broad data base, is required for effective regulation of potential pollutants.

Contribution No. 582, U.S. EPA Environmental Research Laboratory, Gulf Breeze, Florida 32561.

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